**What is claimed is:**

1. A system for monitoring fluids in a fluid processing system comprising:

at least one ultrasound probe comprised of an emitting transducer and a receiving transducer;

a signal processing unit attached to said at least one ultrasound probe, said unit comprised of at least a function generator, a dual channel analog-to-digital converter, and an interface processor;

a computing system adjacent to said signal processing unit, said computing system receiving digitized signal information from said signal processing unit; and

a thermistor attached to said signal processing unit to measure the temperature of said fluid;

wherein, said function generator generates a power signal to activate said emitting transducer to emit an ultrasound wave of specific frequency over a specific time period repeatedly through said fluid to be received as a receiving signal by said receiving transducer;

wherein, said analog-to-digital converter digitizes said power signal as an excitation signal at a specific sampling frequency;

wherein, said analog-to-digital converter digitizes said receiving signal received by said receiving transducer at a specific sampling frequency;

wherein, said computing system computes transmission time and phase shift between said excitation and receiving signals; and

wherein, said computing system uses said phase shift measurement to compute sound velocity, density, compressibility, and solute concentration measurements of the fluid at a measured temperature.

2. The system of claim 1, wherein said fluid processing system is a chemical processing system.

3. The system of claim 2, wherein said fluid is a chemical solution.

4. The system of claim 2, wherein said fluid is oil.

5. The system of claim 2, wherein said fluid is paper slurry.

6. The system of claim 1, wherein said fluid processing system is a biological fluid processing system.

7. The system of claim 6, wherein said fluid is blood.

8. The system of claim 6, wherein said fluid is a food product.

9. The system of claim 1, wherein said at least one ultrasound probe is calibrated using an in-factory calibration procedure using at least two test fluids to assess two constants for converting phase shift measurement to sound velocity, density, or solute concentration.

10. The fluid monitoring system of claim 1, wherein said at least one ultrasound probe is calibrated using an on-line calibration procedure using at least one test fluid injected into said fluid processing system at a site upstream of said at least one ultrasound probe.

11. The system of claim 10, wherein injection of said at least one test fluid into facilitates quantification of specific solutes in said test fluid by said signal processing unit.

12. The system of claim 10, wherein said at least one ultrasound probe is two probes, said two probes placed in series to measure changes in density due to the passage of said at least one test fluid.

13. The system of claim 1, further comprised of an amplifier, said amplifier amplifying said receiving signal from said receiving transducer and directing said receiving signal to said analog-to-digital converter.

14. The system of claim 1, wherein said signal processing unit is built into an IC chip.

15. The system of claim 1, wherein both said emitting signal and said excitation signal are continuous waves.

16. The system of claim 1, further comprised of a light-emitting mechanism, wherein said mechanism induces absorbance and/or reflectance of light in said fluid.

17. The system of claim 16, wherein said light-emitting mechanism is an optical detector, said optical detector comprised of at least one light-emitting diode and at least two photodiodes.

18. The system of claim 16, wherein said light-emitting mechanism is a spectrophotometer, said spectrophotometer comprised of at least one light source, at least one filter, and at least two photomultipliers.

19. The system of claim 16, wherein said computing mechanism uses said density measurement and said absorbance and/or reflectance measurement to monitor passage of a specific solute through said fluid processing system.

20. The system of claim 1, further comprising a conductivity/impedance monitoring device, said device comprised of a pair of electrodes and electronics, wherein said ultrasound probe works in conjunction with said conductivity/impedance monitor to assess conductivity and impedance of fluid.

21. The system of claim 20, wherein said computing system uses said density measurement and said conductivity measurement to monitor passage of a specific solute through said fluid processing system.

22. The system of claim 1, further comprised of a radioactivity counter and a radioactivity source.

23. The system of claim 22, wherein said radioactivity counter works in conjunction with said ultrasound probe to assess radioactivity attenuation of fluid.

24. The system of claim 22, wherein said radioactivity counter works in conjunction with an optical detector to measure concentration of dye and radioactive tracer in said fluid.

25. The system of claim 1, wherein said at least one ultrasound probe is a clip-on configuration.

26. The system of claim 25, wherein said probe has no contact with flowing fluid and imposes no contamination to said fluid.

27. The system of claim 1, wherein said at least one ultrasound probe is a cuvette configuration.

28. The system of claim 27, wherein said cuvette is placed in a temperature-controlled environment.

29. The system of claim 1, wherein said at least one ultrasound probe is mounted at the end of a chromatography column to control collection of specific solutes or a solution containing no solutes.

30. The system of claim 1, wherein said ultrasound probe is an insertion probe.

31. A system for monitoring density and solute concentration of a fluid in a fluid processing system comprising:

at least one ultrasound probe comprised of an emitting transducer and a receiving transducer;

a signal processing unit attached to said at least one ultrasound probe, said unit comprised of at least a function generator, an amplifier, a dual channel analog-to-digital converter, and an interface processor;

a computing system adjacent to said signal processing unit, said computing system receiving digitized signal information from said signal processing unit; and

a thermistor attached to said ultrasound probe to measure the temperature of said fluid;

wherein, said function generator generates a power signal to initiate said emitting transducer to emit ultrasound wave of specific frequency over a specific time period repeatedly through said fluid to be received as a receiving signal by said receiving transducer;

wherein, said analog-to-digital converter digitizes said power signal as an excitation signal at a specific sampling frequency;

wherein, said analog-to-digital converter digitizes said receiving signal, said receiving signal having been received by said receiving transducer at a specific sampling frequency and amplified by the amplifier;

wherein, said computing system computes transmission time and phase shift between said excitation and receiving signals; and

wherein, said computing system uses said phase shift measurement to compute sound velocity, density, compressibility, and solute concentration measurements of the fluid at the measured temperature.

32. A process for monitoring fluid in a fluid processing system, comprising the steps of:

calibrating an ultrasound probe in-factory with at least two in-factory calibrating fluids of known sound velocity to assess phase shift of fluid in terms of sound velocity of said fluid;

calibrating said ultrasound probe on-line with at least one on-line calibrating fluid to assess phase shift of fluid in terms of density of said fluid;

exposing said ultrasound probe into said fluid of said fluid processing system, wherein said ultrasound probe is comprised of an emitting transducer and a receiving transducer and is attached to a signal processing unit comprised of at least a function generator, an amplifier, a dual channel analog-to-digital converter, and an interface processor;

generating a power signal from said generator, wherein said power signal initiates said emitting transducer to repeatedly emit over a specific time period an ultrasound wave of specific frequency through said fluid to be received as a receiving signal by said receiving transducer;

digitizing said power signal as an excitation signal via said analog-to-digital converter;

amplifying said receiving signal via said amplifier;

digitizing said amplified receiving signal via said analog-to-digital converter;

transferring said digitized excitation signal and receiving signal to said interface processor;

transferring said digitized excitation signal and receiving signal data to a computing system, wherein said computing system computes transmission time and phase shift between said excitation and receiving signals, and wherein, said computing system uses said phase shift measurement and said calibrating fluid measurements to compute sound velocity, density, compressibility, and solute concentration measurements of the fluid at a measured temperature.

33. The process of claim 32, wherein said fluid processing system is a biological or chemical reactor.

34. The process of claim 32, wherein said fluid processing system is a column of a liquid chromatography system.

35. The process of claim 32, wherein said fluid processing system is a mixing chamber.

36. The process of claim 32, wherein said fluid processing system is a cooking vessel.

37. The process of claim 32, wherein said fluid is blood.

38. The process of claim 32, wherein said fluid is a chemical solution.

39. The process of claim 32, wherein said fluid is oil.

40. The process of claim 32, wherein said fluid is a paper slurry.

41. The process of claim 37, wherein said computing system determines density, total protein content, hematocrit, plasma density, and plasma protein concentration measurements of said blood.

42. The process of claim 41, wherein changes in blood volume in total circulation and in microcirculation during a clinical treatment is determined using said measurements and said at least one test fluid.

43. The process of claim 41, wherein changes in blood volume and pooling of blood in microcirculation are monitored using said measurements of density and hematocrit of said blood.

44. The process of claim 32, wherein said calibrating of said ultrasound probe comprises injecting said at least one calibrating fluid into said fluid of said fluid processing system upstream of said ultrasound probe.

45. The process of claim 32, wherein said at least one calibrating fluid is two calibrating fluids.

46. The process of claim 44, wherein said two calibrating fluids have different solute concentrations.

47. The process of claim 32, further comprised of placing at least two ultrasound probes in series to measure changes in density due to passage of a test fluid injected upstream of said ultrasound probes.

48. The process of claim 32, further comprised of monitoring temperature of said fluid of said fluid processing system, wherein said temperature is used by said computing system to convert sound velocity measurements of said fluid to density, compressibility, and solute concentration measurements of said fluid.

49. The process of claim 48, wherein said temperature is monitored using a thermistor attached to said fluid processing system.

50. The process of claim 32, wherein said computing system uses information from said ultrasound probe in conjunction with information from a mechanical density measuring system to convert measurements of sound velocity and phase shift to measurements of density, compressibility, and solute concentration of said fluid.

51. The process of claim 32, wherein said ultrasound probe is exposed to said fluid of said fluid processing system in a temperature-controlled environment.

52. The process of claim 32, further comprised of integrating further detection modality measurements with measurements of said ultrasound probe to monitor passage of a specific solute through said fluid processing system.

53. The process of claim 52, wherein said detection modality measurement is optical absorbance and/or reflectance.

54. The process of claim 53, wherein an optical detector determines optical density from said absorbance and/or reflectance measurement.

55. The process of claim 54, further comprised of on-line calibration of said optical density measurement of said optical detector with said density measurement of said ultrasound probe, wherein said at least one test fluid is injected into said fluid processing system.

56. The process of claim 52, wherein said detection modality measurement is microwave conductivity and/or impedance.

57. The process of claim 52, wherein said detection modality measurement is magnetic resonance.

58. The process of claim 52, wherein said detection modality measurement is radiation attenuation.

59. The process of claim 52, wherein said detection modality measurement is tracers of fluid.

60. The process of claim 52, further comprised of activating of a fractional collector to collect solution containing most of said specific solute.

61. The process of claim 60, wherein said activating collection of a specific solute solution improves purity of a specific solute.

62. The process of claim 37 wherein said at least one on-line calibrating fluid is isotonic saline or dialysate.

63. The process of claim 38 wherein said at least one on-line calibrating fluid is a base solution.

64. The process of claim 33 wherein said at least one on-line calibrating fluid is a fluid containing tracers or markers used to assess reaction properties of a chemical or biological processing system.

65. The process of claim 62, further comprised of diluting said fluid of said fluid processing system using a dilution procedure wherein a known volume of said saline or dialysate is infused into said fluid processing system for use in computing blood volume of an animal.